THE EFFECTS OF COGNITIVE FLEXIBILITY TRAINING ON CREATIVITY

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General-Experimental

by

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DEDICATION

This thesis is dedicated to: the many people, family and friends in my life who continue to support me in pursuit of my academic career and to those who continue to inspire me to follow my passion and dreams. Thank you!
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature Page</td>
<td>ii</td>
</tr>
<tr>
<td>Dedication</td>
<td>iii</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>iv</td>
</tr>
<tr>
<td>List of Appendices</td>
<td>vi</td>
</tr>
<tr>
<td>List of Tables</td>
<td>vii</td>
</tr>
<tr>
<td>Abstract</td>
<td>viii</td>
</tr>
<tr>
<td><strong>CHAPTER I – INTRODUCTION</strong></td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>2</td>
</tr>
<tr>
<td>Purpose</td>
<td>2</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>2</td>
</tr>
<tr>
<td>Assumptions</td>
<td>3</td>
</tr>
<tr>
<td><strong>CHAPTER II – REVIEW OF LITERATURE</strong></td>
<td>4</td>
</tr>
<tr>
<td>Defining Creativity</td>
<td>4</td>
</tr>
<tr>
<td>Divergent Thinking Tasks</td>
<td>5</td>
</tr>
<tr>
<td>Expertise and Creativity</td>
<td>7</td>
</tr>
<tr>
<td>Stages of Creativity</td>
<td>8</td>
</tr>
<tr>
<td>Fostering Creativity</td>
<td>10</td>
</tr>
<tr>
<td>Cognitive Flexibility</td>
<td>11</td>
</tr>
<tr>
<td><strong>CHAPTER III – METHODOLOGY</strong></td>
<td>13</td>
</tr>
<tr>
<td>Pilot Study</td>
<td>13</td>
</tr>
<tr>
<td>Participants</td>
<td>13</td>
</tr>
<tr>
<td>Materials</td>
<td>13</td>
</tr>
<tr>
<td>Design and Procedure</td>
<td>15</td>
</tr>
<tr>
<td>Final Study</td>
<td>17</td>
</tr>
<tr>
<td>Procedure</td>
<td>18</td>
</tr>
<tr>
<td>Measurements</td>
<td>20</td>
</tr>
<tr>
<td><strong>CHAPTER IV – RESULTS</strong></td>
<td>24</td>
</tr>
<tr>
<td>Pilot Study – Results</td>
<td>24</td>
</tr>
<tr>
<td>Present Study – Results</td>
<td>27</td>
</tr>
<tr>
<td><strong>CHAPTER V – DISCUSSION</strong></td>
<td>33</td>
</tr>
<tr>
<td>Discussion</td>
<td>33</td>
</tr>
<tr>
<td>Research Implications</td>
<td>37</td>
</tr>
<tr>
<td>Limitations</td>
<td>38</td>
</tr>
<tr>
<td>Conclusion</td>
<td>38</td>
</tr>
<tr>
<td><strong>REFERENCES</strong></td>
<td>40</td>
</tr>
<tr>
<td>Appendix A – Pilot study puzzle-task</td>
<td>47</td>
</tr>
<tr>
<td>Appendix B – Hand drawing for thumbs problem</td>
<td>48</td>
</tr>
<tr>
<td>Appendix C – Brainstorming “Time” Article</td>
<td>49</td>
</tr>
</tbody>
</table>
Appendix D – Practice puzzle-task (Pilot study)  52
Appendix E – Low Flexibility Puzzle-task (Pilot study)  53
Appendix F – High Flexibility Puzzle-task (Pilot study)  54
Appendix G – Practice Puzzle-task (Present study)  55
Appendix H – Low Flexibility Puzzle-task (Present study)  56
Appendix I – High Flexibility Puzzle-task (Present study)  57
Appendix J – Demographics Questionnaire  59
LIST OF TABLES AND FIGURES

Table 1 – *Pilot Study*: Means and Standard Deviation of Scores 23

Figure 1 – *Pilot Study*: Mean Number of Times the Puzzle-task was Solved 24

Figure 2 – *Pilot Study*: Mean Number of Ideas Generated 24

Figure 3 – *Pilot Study*: Mean Number of Creative Ideas Generated 25

Table 2 – *Present Study*: Means and Standard Deviation of Scores 28

Table 3 – *Present Study*: Time Scores (Means and Standard Deviations) 29

Figure 4 – *Present Study*: Mean Number of Ideas Generated 31
ABSTRACT

THE EFFECTS OF COGNITIVE FLEXIBILITY TRAINING ON CREATIVITY

by

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Previous research suggests that one of many key elements necessary for creative behavior is cognitive flexibility (i.e., the ability to move in and out of categories that become less and less associated with the given task stimuli; Lamm & Trommsdorf, 1973). However, little research has examined whether cognitive flexibility could be improved through cognitive training to enhance creative performance. The present study aimed to investigate whether varying levels of cognitive flexibility training could improve flexible thinking and lead to greater ideational fluency and creative performance on subsequent brainstorming tasks. In the present study, by manipulating the level of cognitive flexibility, participants ($N = 73$) were randomly separated into two groups (Low and High Flexibility groups). The cognitive flexibility puzzle-task (Gonzalez, Pratt, Benson, Figueroa, Rhodes, & Youmans, 2012) training session was followed by a brainstorming task to examine the effects of training on subsequent brainstorming tasks. Results from the experiment suggest that the cognitive flexibility training was not sufficient to produce significant differences between the Low and High Flexibility groups on measures of creativity. Despite the lack of evidence to support the hypotheses, future studies and implications are discussed.
CHAPTER I
INTRODUCTION

Creative behavior is often associated with art, music, literature, and other fine arts, but creativity is also important in science and industry. Continual innovations and resourcefulness have become necessary for the growth of many modern economies (Craft, 2003), and many innovators (e.g., Einstein, Tesla, Poincaré, Picasso) developed and produced renowned inventions and revolutionary ideas that have literally changed the way people live (Ericsson, 1999). Because of the importance of creative behavior to art, science, and industry, psychologists have long sought to understand what drives creativity in some people and produces less creativity in others (McCrae, 1987).

A guiding principle among creativity researchers has been that certain mental characteristics predispose individuals to more or less creative behavior, that is, while all people can act creatively, certain mental characteristics make some people more creative (Amabile, 1983). For instance, researchers have found extraverts to be more creative than introverts, and that those who are high in openness to experience tend to be more creative than those who are low in openness to experience (De Dreu, Nijstad, & Bass, 2011).

Despite the vast literature on creativity, however, researchers still have not been able to fully explain the creative process (Csikszentmihalyi & Getzels, 1971). Recent research suggests that neither personality traits nor general ability fully explain creative output, but rather, that creative endeavors are more likely the result of a complex combination of personal characteristics, cognitive abilities, and social environments (Amabile, Conti, Coon, Lazenby, & Herron, 1996; Csikszentmihalyi, 1997). Smith, Ward, and Finke (1995) reported that there are varying circumstances that lead to creative
outcomes, and Ericsson (1999) suggests that experts in particular domains maintain certain necessary conditions that allow for creative behaviors to surface. These and other researchers argue that creative behaviors only occur after interactions between underlying cognitive structures and the processing of old and new information.

**Purpose**

The purpose of this thesis was to examine whether cognitive flexibility could be improved via training on computerized puzzle-tasks, and whether higher flexible thinking led to better creative performance on subsequent divergent thinking tasks. This thesis reviews literature on definitions of creativity, the creative process, divergent thinking, and whether cognitive training in flexible thinking would be an effective method for facilitating creativity. An experimental study was employed to examine whether training in a computer-based cognitive flexibility puzzle-task (Gonzalez, Pratt, Benson, Figueroa, Rhodes, & Youmans, 2012) could increase levels of creative performance on brainstorming tasks. The findings from this study may have implications in educational settings along with educational and instructional tools for improving and fostering creativity across different domains.

**Hypotheses**

**Research Hypotheses**

Based on the review of literature in Chapter 2, the following research hypotheses were developed.

1. Individuals in the High Flexibility Puzzle group would generate greater frequency of ideas than the Low Flexibility Puzzle group.

2. Individuals in the High Flexibility Puzzle group would produce higher levels of
creativity than the Low Flexibility group.
CHAPTER II
REVIEW OF LITERATURE

Defining Creativity

There are over a hundred varying definitions of creativity in the literature. Creative performance has been extensively researched in numerous domains such as science, chess, sports, and music (Ericsson, Krampe, & Tesch-Römer, 1993; Memmert, 2011; Runco, 1996). Creativity has been difficult to define in previous research because of its varying complexity that may have led to some inconsistencies in the literature. For instance, Amabile (1983) suggested that researchers should take into account not only an explicit operational definition of creativity in empirical research, but also three factors of creativity that include: (a) the creative process, (b) the creative person, and (c) the creative product. Similarly, Csikzentmihaly and Getzels (1971) reported that defining creativity lies in observable behaviors or responses, such as the examination and quality of a creative product.

Other researchers have defined creative behavior in terms of the frequency of ideas (Guilford, 1967). For example, Gluck, Ernst, and Unger (2002) found ways to systematically define creativity by having “free” artists (e.g., painters, sculptors), “constrained” artists (e.g., architects or designers), and students fill out the German Definitions of Creativity Questionnaire (DOCQ; Gluck, 1996a, 1996b). The DOCQ is a short quantitative and qualitative assessment of a person’s individual conception of creativity (Gluck, 1996a, 1996b). Across the three groups, all agreed that the creative person must generate many ideas (Gluck et al., 2002). Researchers have also suggested that creativity involves the recognition of ideas by peers or experts in that particular
domain, and suggested that creativity is a form of problem solving ability (Tyler, 1978). According to Mumford and Gustafson (1998), creativity is achieved when humans are able to find ways through problems that may not already have a solution or improve on an existing creation.

The problem of operationally defining creativity poses as a challenge in research. Regardless, the ability to create is an integral part of human behavior. In the arts and sciences, creative output has led to major contributions in these fields, and the creative product or response is deemed creative when it has some quality and or value in society (Scott, Leritz, & Mumford, 2004). However, the general consensus is that creativity is simply the production of something that is both original and useful (Mumford, 2003; Sternberg & Lubart, 1999).

**Divergent Thinking Tasks**

One form of measuring creativity is with the use of divergent thinking tasks (e.g., Unusual Uses Task, Torrance Tests of Creative Thinking), which examine the generated number of solutions that a person can come up with to a given problem and are typically used in studies to assess individual differences in levels of creative performance (Silvia et al., 2008). For example, the Unusual Uses Task takes a common object such as a bucket and requires that the participant come up with as many uses as possible (e.g., stepping stool, carrying water, helmet; White & Shah, 2006).

Creative performance is often measured by examining creative insights, original ideas, and the frequency of ideas (Runco, 1996; Torrance, 1966; 1974). In addition, researchers argue that creative tasks should have open-ended responses, which allow for a considerable amount of flexibility (Amabile, 1982). Researchers also suggested that
divergent thinking tasks are a valid way to measure creativity and are high in predicting creative traits and or skills in a person. These types of tasks allows for the responses to be scored for fluency (i.e., number of responses), originality (i.e., uniqueness of responses), flexibility (i.e., category shifts between responses), and elaboration (i.e., refinement of responses), all of which are indications of creative problem solving ability and creative performance (Scott, Leritz, & Mumford, 2004; White & Shah, 2006).

Cliatt, Shaw, and Sherwood (1980) wanted to understand whether the effects of training children on divergent thinking strategies would subsequently show higher levels of creative performance using the Torrance Test of Creative Thinking (TTCT) as a measure. The TTCT was designed as part of a long-term research program to increase classroom experiences that stimulate creative thinking, by measuring both verbal and figural categories in creativity (Kim, 2006). The teachers in the study were trained to engage the children in specific exercises that would potentially enhance creative thinking (Cliatt et al., 1980). For example, the children in the experimental group were told to come up with their own ending to a story, while the control group was not given the exercise to think divergently. The training took place in the classrooms once a week over the course of eight weeks with pretests and posttests to measure whether there were long-term effects of training. Significant differences between the two groups were found, suggesting that training even at early developmental stages can increase the ability of children to think divergently and possibly show long term transfer effects of creativity training.

In a previous study looking at individual differences between gifted, non-gifted, and talented children, Runco (1987) examined whether maximal creative performance
could be achieved in divergent thinking tasks by explicitly instructing them to “be creative” and “give only original responses.” Children were given a battery of divergent thinking tasks (i.e., Instances, Pattern-Meanings, Uses, Similarities, and Line-Meanings). They were also given standard instructions that instructed them to do nothing more than write down their ideas (e.g., Harrington, 1975) with no time constraints, and they were told that there were no correct or incorrect responses. Runco (1987) found a significant effect of the explicit instructions on originality scores compared to scores in the standard instruction condition (i.e., “write down your ideas”). These differences could be attributed simply to the explicit instructions that prime the students to be creative. However, Runco also found that the explicit instructions significantly inhibited the children’s performance in fluency and flexibility compared to those who were given standard instructions. Nonetheless, in general these studies suggest that divergent thinking skills can be increased when given training sessions and explicit instructions, which may enhance creative performance.

**Expertise and Creativity**

Expertise may be a mediating factor for creativity because it is possible to enhance and/or achieve creative performance (e.g., creative fluency and originality) through deliberate and sustained attention in a particular domain (De Dreu, Baas, & Nijstad, 2008). Scientific evidence has suggested that in virtually any domain, individuals can attain expert levels of performance, which results from extended engagement in high quality training (i.e., deliberate practice) (Ericsson, Krampe, & Tesch-Römer, 1993; Memmert, 2011). There have been a number of self-reports and interviews with numerous creative individuals who have contributed notable (i.e., creative) works to their
domain because of their expertise (Csikszentmihalyi, 1997).

Research has shown that careful examinations of those who have made recognized creative contributions have spent a significant and considerable amount of time committed to their domain on the order of days, months, and even years (Mumford, & Gustafson, 1988). Those who have achieved this expert level of performance described their daily activities, which included high levels of sustained intentional effort to the domain (e.g., 10,000 hours or 10 years of deliberate practice); thus they were able to achieve and generate creative innovations that were eminent to that domain because they maintained conditions that were necessary and likely for creative behavior to emerge (Ericsson, 1998; 1999). For example, Ericsson et al. (1993) conducted a study by examining four groups of violinists (i.e., best students, good students, music teachers, and professionals) who were required to keep a diary of time spent on their daily activities. Through qualitative analysis, Ericsson et al. found that those deemed to perform equally to that of professionals were the “best” students—characterized by spending the most time committed to deliberate practice as a function of their daily activities.

**Stages of Creativity**

The creative process is described as a sequence of steps that involves actions and cognitive processes that result in the production of something original and useful (Lubart, 2001). The stages of creativity may be unclear as to what exactly happens during the creative process. However, there is evidence that has identified a four-stage model that contains four important stages in the creative process and they are generally referred to as (a) preparation, (b) incubation, (c) insight (i.e., discovery or illumination), and (d) verification (i.e., concretization) (Csikzentmihalyi, 1997; Guilford, 1950). According to
Csikszentmihaly (1997), the *preparation* stage of the creative process is when the person is either consciously engaged in a problem or set of problems, which can also be identified as *problem finding*. Henri Poincaré, a French mathematician, who commented about his own creative process, recorded early examples of this stage in problem finding. Poincaré stated that the first stage of the creative process was initiated with conscious effort towards a problem, and much of his work was started by trying to prove that Fuchsian functions could not exist (Ghiselin, 1952; Lubart, 2001).

This conscious effort and period of intensive work is often followed by an *incubation* period. The incubation period is the second stage of the creative process and is often described as the unconscious process in which the person is not actively thinking about the problem or when no active attempts have been made, thus allowing the flow of ideas and associations from the unconsciousness into the consciousness (Csikzentmihaly, 1997; Mumford & Gustafson, 1988). Often times, the incubation process can be the result of unsuccessful attempts at a problem during a period of sustained intentional effort, allowing the person to mentally and/or physically break set and return to the problem at a later point in time (Mednick, Mednick, & Mednick, 1964). The effects of the incubation period have been shown to enhance creativity in various domains. For example, Smith and Blankenship (1989) suggested that incubation periods that occur between problem solving and during functional fixedness (i.e., the fixation of preexisting ideas) result in increased problem solving performance and decreased fixation effects.

The third stage in the creative process is referred to as *insight or illumination* and typically occurs when a solution(s) to a problem suddenly manifests into the
consciousness (Csikzentmihaly, 1997). Self-reports of insight were often described as the sudden realization of a solution to a problem in an “Aha!” or “Eureka” moment, and much of this has been documented in studies that look at insight problem solving (Dow & Mayer, 2004).

The fourth and final stage of the creative process is the applicability of the product or response and is typically called the *verification* stage. Some suggest that the process of creativity is not fully completed until “concretization” takes place, which may result in the form of a product or response (Morgan, 1953). The concretization of creative response or product then finally goes through a process in which “gatekeepers,” who typically are experts from that particular field, judge whether the response or product is deemed creative (Amabile, 1983).

**Fostering Creativity**

There are many benefits to fostering creativity. For example, in organizational settings, an environment that promotes creativity allows for individuals to develop creative thinking skills necessary for creative performance on various tasks (Lewis, 2006). However, little is known about whether certain conditions enhance creative performance, and it is unclear whether creativity training demonstrates short-term or long-term effects. Researchers have investigated methods for improving creativity within a variety of settings, with mixed results. For example, Shalley (1995) examined whether creativity could be fostered in organizational settings and discovered that under certain environmental conditions, creativity levels were highest when individuals had a creativity goal and worked alone with the expectation of evaluation.

In educational settings (e.g., classrooms), Baer (1993) found that having students
engage in task-specific training improved their level of flexibility, originality, elaborative skills, and specifically poetry-relevant tasks. Baer also discovered that the effects of the task-specific training showed a significant increase in creative performance for the poetry relevant task. However, Baer found no significant difference in the story-writing task, suggesting that domain specific training may not transfer broadly over to other domains.

In an earlier study, Baer (1988) investigated the long-term effects of a creativity-training program by having students train over a period of three days on a variation of the Creative Problem Solving Task (CPS), which emphasized both convergent and divergent thinking tasks. After six months, the experimental group was tested again to examine the long-term effects of creativity training. The results showed a statistically significant higher overall gain for the experimental group, which suggests that continued creativity training could have long-term implications.

Cropley and Cropley (2000) conducted a study that involved using lectures on creativity as a training tool to foster creative behavior. Cropley and Cropley found that students in the experimental group who received the creative lecture material were significantly more creative on the subsequent product design task than the control group who received no form of training. Having the students learn the lecture material that covered topics of creativity seemed to have an effect on their creative behavior. In domains such as design and engineering, the product is based on the merit of creativity and functionality, and such training could help foster higher levels of creative behavior.

**Cognitive Flexibility**

Cognitive flexibility is the ability to abandon one strategy in favor of a more optimal strategy (Scott, 1962). Not only is cognitive flexibility necessary for breaking old
cognitive patterns, but it relates positively to creative performance (Guilford, 1967). In addition, research has shown that flexible thinking predicts creative performance, the ability to generate new ideas, and the ability to find multiple ways to use one idea (DeDreu et al., 2007; Hirt, Devers, & McCrea, 2008). It was also found that that positive mood results in flexible thinking and helps people balance goals, stress levels, and pressure (Dreishbach & Goschke, 2004).

Some researchers found that having experiences that were defined as highly unusual and unexpected events (e.g., early parental loss, living abroad, having an immigrant status) were more likely to be creative because the experience was beyond the boundaries of normal daily experiences (Goertzel, Goertzel, & Goertzel, 1978; Leung, Maddux, Galinsky, & Chiu, 2008). Ritter et al. (2012) found that individuals in the Active-Unexpected-Events condition were more cognitively flexible and had significantly more ideas (verbal fluency) than the Active-Normal-Events and Vicarious-Unexpected Events conditions. However, rather than examining individual differences in creativity, the goal of the present study is to examine whether encouraging cognitive flexibility as a cognitive training tool can increase levels of creative behavior.
CHAPTER III

METHODOLOGY

Pilot Study

The following method described was part of a pilot study that was conducted to ensure the usability of the puzzle-task and was the first prototype (developed by Figueroa & Youmans, 2011).

Participants

Fifty-two participants from California State University Northridge were recruited from the subject pool through the university SONA system. All participants were open to participating in the study. Of the \( N = 52 \) participants, there were 19 males and 33 females, age \( M = 21 \) years with a range of 18-43 years.

Materials

Puzzle-task. An experimental measure of cognitive flexibility was utilized, using a computer-based puzzle that was originally developed by Figueroa and Youmans (2011) to focus specifically on the types of cognitive flexibility similarly required for optimal performance in the Wisconsin Card Sorting Task (Grant & Berg, 1948). In order to advance through the puzzle grid, participants must move through a maze of different shapes and color combinations, by matching the shape (i.e., triangle, circle, 5-point star), shape color (i.e., green, red, blue), or background color (i.e., light green, light red, light blue) of the squares in the maze (see APPENDIX A). Because successful performance requires frequent changes in strategy, cognitive flexibility is assessed by how quickly a participant finishes the puzzle-task. However, the first puzzle-task prototype used for the pilot study did not have a function to record the time it took to solve the puzzle or a
function to record whether an error was made when the participant selected the incorrect space. Instead, during each trial block participants were allotted ten minutes to complete the puzzle-task successfully as many times as they could, and the experimenter recorded the number of times each participant successfully completed the puzzle-task within the ten minutes. The puzzle-task allows the experimenter to manipulate three parameters of the puzzle that includes grid size (i.e., size of the puzzle) (e.g., 4x5), the path size (i.e., number of spaces to solution), and the number of strategy switches required. In addition, a “fog of war” element was programmed to only display surrounding spaces as the participant advances through the puzzle. This feature was implemented to prevent participants from planning ahead in the puzzle-task. The latest puzzle-task prototype was used for the final study.

**Brainstorming Tasks**

Three brainstorming tasks were used from a previous study conducted by Taylor, Berry, and Block (1958), and portions of the procedures were replicated in the present study. The three brainstorming tasks were each a consequences hypothetical event (e.g., what if…), and each presented a different problem (i.e., Teacher Problem, Thumbs Problem, and Tourists Problem), and the presentation was counterbalanced to avoid any order effects. According to Taylor et al., Osborn (1953) and Yale graduate students selected the brainstorming problems because all agreed that each of the three problems presented and maintained concepts of brainstorming.

**Teacher’s problem.** The teacher’s problem follows: “Because of the rapidly increasing birth rate beginning in the 1990’s, it is now clear that by 2020 public school enrollment will be very much greater than it is today. In fact, it has been estimated that if
the student-teacher ratio were to be maintained at what it is today, 50 percent of all individuals graduating from college would have to be induced to enter teaching. What different steps might be taken to insure that schools will continue to provide instruction at least equal in effectiveness to that now provided?"

The teacher’s problem was slightly altered in terms of years to keep this problem as current as possible. The rapid birth rate year was changed from 1940’s to 1990’s and the increase in public school enrollment was changed from 1970 to 2020.

**Thumbs’ problem.** The thumbs’ problem follows: “We don’t think this is very likely to happen, but imagine for a moment what would happen if everyone born after 2014 had an extra thumb on each hand. This extra thumb will be built just as the present one is, but located on the other side of the hand. It faces inward, so that it can press against the fingers, just as the regular thumb does now. Here is a picture to help you see how it will be. Now the question is: What practical benefits or difficulties will arise when people start having this extra thumb?”

The thumbs’ problem was slightly altered from “everyone born after 1960” to ‘2014’ to adjust for the present study. An outline drawing of a hand with two thumbs was provided for each participant (see APPENDIX B).

**Tourists’ problem.** The tourists’ problem follows: “Each year a great many American tourists go to visit Europe. But now suppose that our country wished to get many more European tourists to come to visit America during their vacations. What steps can you suggest that would get more European tourists to come to this country?”
Design and Procedure

The pilot study was an experimental study designed to establish whether engaging in more flexible thinking on the puzzle-task (Figueroa & Youmans, 2011) leads to more creative ideas on subsequent brainstorming problems used in Taylor et al. (1958). Prior to the study, informed consent was obtained from the participants. To keep similar methods used by Taylor et al., participants upon sitting down read the first three paragraphs (about 60 percent) of a *Time* article on Brainstorming (1957) (see APPENDIX C) prior to starting the experiment to ensure that all participants had a conceptual knowledge of brainstorming and creative thinking. The two experimental groups were tested side-by-side, and a desk divider was utilized to occlude each participant from viewing the person sitting next to him/her. To avoid any possible cheating during both the puzzle-tasks and the brainstorming tasks, an experimenter was present during all the trials. Using random assignment, neither group had any knowledge of which condition they were placed in. After both participants were finished reading the *Time* article, participants were then given a tutorial on how to successfully complete the puzzle-task. Following the tutorial, participants then engaged in one practice puzzle to familiarize themselves with the interface and rules. During the practice session, both groups had the same puzzle-task parameters maintaining a grid size of 8x8 (64 squares), a path size of 15 (i.e., the number of spaces to the solution), and the number of changes was five (i.e., the number of strategy changes that is randomly assigned throughout the puzzle-task trial) (see APPENDIX D). For the actual experimental trials, puzzle-task parameters maintained a grid size of 13x13 (169 squares) and a path size of 25 for both groups. However, one condition maintained five strategy changes (Low Flexibility) for each puzzle-task trial.
(see APPENDIX E), and the other condition maintained twenty-five strategy changes (High Flexibility) for each puzzle-task trial (see APPENDIX F). Each trial block lasted 20 minutes: ten minutes for the puzzle-task followed with a subsequent brainstorming task for the remaining ten minutes. The three brainstorming tasks were counter-balanced to avoid any order effects.

**Present Study**

**Participants**

Participants \((N = 73)\) over the age of 18 years were recruited from the California State University Northridge through the human subject pool management software for universities. The mean average age was 20.25 years, and the age range was 18-50 years. Of the participants, 21 were male participants and 52 were female participants. The participants were randomly assigned to either the Low Flexibility \((n = 37)\) or the High Flexibility \((n = 36)\) group. Participants were awarded class credit for their participation.

**Puzzle-task**

The puzzle-task developed by Gonzalez et al. (2012) was used in the final study and included several features that were not available in the previous prototype developed by Figueroa and Youmans (2011). For the practice session, both Low and High Flexibility groups engaged in two puzzle-tasks that maintained a grid size 8x8 (64 squares), a path size of 15 (i.e., the number of spaces to the solution), and the number of strategy switches of six (i.e., the number of strategy changes that is randomly assigned throughout the puzzle-task trial) (see APPENDIX G). For the actual experimental trials, puzzle-task parameters maintained a grid size of 10 x 10 (100 squares) and a path size of 19 for both Flexibility groups. However, the Low Flexibility condition required either
two or four strategy switches (10% or 20%) to navigate through the puzzle and was presented in random order for each puzzle-task trial (see APPENDIX H). As for the High Flexibility condition, the number of strategy switches required either 10 or 12 switches (50% or 60%) and was also presented in random order (see APPENDIX I).

Additional options in the final puzzle-task included a variety of object shapes that were not previously available in the pilot study version: alarm bell, fire hydrant, fire extinguisher, anchor, bus, plane, crab, fish, octopus, strawberry, orange, and lime. Additional colors were also added which included: green, yellow, orange, red, light blue, dark blue, purple, pink, and mint green. These features were made available to add increased functionality and engagement. The puzzle-task version that was used in the final study maintained the following colors across the three trial blocks and was programmed to appear at random. The object shapes were programmed differently for each trial block: Trial #1 (lime, fish, anchor), Trial #2 (orange, crab, plane), and Trial #3 (strawberry, octopus, bus). The presentation order was counter-balanced for the preprogrammed puzzle-task trials.

**Procedure**

Each experimental session lasted approximately one hour and 30 minutes. Prior to the study, informed consent was obtained from the participants. The experimenter began all experimental sessions by reading aloud the instructions to replicate the methods used by Taylor et al. (1958). Upon sitting down, participants were instructed to read the first three paragraphs (about 60 percent) of a *Time* (1957) article on Brainstorming (see APPENDIX C) to ensure that all participants had a conceptual knowledge of brainstorming and creative thinking. After participants were finished reading the *Time*
article, participants were told they were going to engage in a puzzle-like activity.

Participants were tested side-by-side in a lab of six Dell OptiPlex 760 computers with three on either side of the room. All participants were placed in cubicles three feet wide with walls between each computer to occlude each participant from viewing the person sitting next to them. In addition, an experimenter was present during all aspects of the experiment to avoid any possible distraction during the puzzle-tasks and cheating during the brainstorming tasks.

Two practice trials were employed to ensure that participants had full understanding of the rules and goals of puzzle-task. During the practice puzzle-task trials, participants were first told that each puzzle would always start in top left corner of the puzzle and always finish at the bottom right. It was also explained that they could only navigate left, right, up, and down (not diagonally). Next, the participants were explained that two adjacent spaces had to follow one of three rules already described in order to successfully navigate through the puzzle, and that one must quickly switch rules to advance to the next available spaces. Then, the participants were told that if they had made an error by clicking the wrong available space, the space would quickly blink for one second and within that duration no moves were allowed, ultimately causing their overall time to complete the puzzle longer. Once participants finished a puzzle, they were instructed to click the top left space to start and begin a new puzzle. The experimenter guided the participants through the first practice puzzle-task and let the participants solve the second puzzle-task on their own.

When the participants were finished with the practice trials, they were told that the goal of the puzzle-task was to finish as many puzzles as quickly and as accurately as
they could within the ten minutes. An opportunity was provided for questions. During the practice puzzle session, all the participants had the same puzzle-task parameters maintaining a grid size of 10x10 (100 squares), a path size of 19 (i.e., the number of spaces to the solution), and the number of changes of six (40%) (i.e., the number of strategy changes that is randomly assigned throughout the puzzle-task trial). For the actual experimental trials, puzzle-task parameters maintained a grid size of 10x10 and a path size of 19 for both groups. However, the Low Flexibility condition maintained between two and four strategy switches (10% & 20%) for each puzzle-task trial, and the High Flexibility condition maintained between ten and twelve strategy switches (50% & 60%) for each puzzle-task trial. Following the puzzle-task, participants then engaged in a brainstorming problem, and the experimenter presented each problem by reading it aloud to the participants. If any questions were raised, of the experimenter responded by rereading part or all of the brainstorming problem. The experimenter then explained that their goal within ten minutes was to brainstorm on their own and come up with as many ideas as they could, that were both novel and useful. The entire procedure was repeated in three trial blocks, and one trial block lasted 20 minutes: ten minutes for the puzzle-task followed by a subsequent brainstorming task for the remaining ten minutes. After completing the experimental session, the participants were given a post questionnaire to gather demographics and information regarding the participants’ motivation and enjoyment during both the puzzle-tasks and brainstorming problems.

**Measurements**

**Puzzle-task.** After each puzzle trial block, the computer generated a row of data for each puzzle-task trial (i.e., one puzzle) that was completed by the participant, and
each row indicated that the participant had completed a puzzle. If the participant did not finish a puzzle when the ten-minutes were up, a negative number tied to that trial indicated the unfinished puzzle and was not counted. The completed puzzles were then tallied to generate the participants’ final number of completed puzzle-tasks within the trial block.

**Time.** The puzzle-task records time in milliseconds for a number of variables. The puzzle records the overall time it takes for the participant to complete each puzzle-task (i.e., one puzzle). The puzzle-task also records the average time it takes per move for each puzzle. In addition, the puzzle-task records the average time to make a perseverative move, which is when a strategy switch is required in order to make a successful move. Conversely, the puzzle records the average time to make a non-perseverative move, which is when a strategy switch is not required to make a successful move.

**Errors.** An error during the puzzle-task occurred when the participant selected a move that did not follow one of the three switching rules. When an error was made, the selected space would rapidly blink for one second and no spaces could be selected during the error. The computer generated the number of errors made for each puzzle-task trial, and a proportion for the errors was computed for the raw error score for each trial block.

**Ideas.** The experimenter, who had no knowledge of which participants were placed in which experimental group, counted the frequency of ideas generated by each of the participants. When a participant repeated an idea, it was only counted as one idea and not two. However, if the participant generated a similar idea, but added something else to the idea, it was counted as a separate idea.

**Creativity.** The experimenter determined the level of creativity for each idea that
was generated for the three brainstorming problems. To do so, the experimenter created a list of the total set of all the ideas that participants generated, then he gave each idea a numerical score based on the rarity of each idea. For instance, if the participant generated an idea and it was the only one that occurred in the master list, then the idea was given a score of one. However, if the participant generated an idea that many other participants had also thought of, then that idea was given a score that reflected the number of times that the idea occurred in the master list.

**Video games.** Self-report measures were obtained from participants regarding video game playing behavior to test for the possibility that participants’ experience playing video games would correlate with their performance on the puzzle-tasks or brainstorming problems. Specifically, participants were asked whether they engaged in playing video games, what genre of video games they typically played, how often they engaged in playing video games during a typical week, and how many hours they played at any given time (see APPENDIX J). The genre of video games included: action-adventure, adventure, strategy, puzzles, shooters, role-playing, massive multiplayer online role playing game, racing, and music playing. The question regarding the participants’ behavior playing video games in a typical week had the following response choices: once a week, 1-2 times a week, 3-4 times a week, and 4+ times a week. Also, participants were asked how many hours they played video games (or puzzles) at any given time with the following response options: 0-1 hour, 1-2 hours, 3-4 hours, 4-5 hours, 5-6 hours, 6-7 hours, 8+ hours.

**Puzzles games.** Participants were asked how many times they engaged in puzzles (i.e., sudoku, crosswords, scrabble) in a typical week: once a week, 1-2 times a week, 3-4
times a week, and 4+ times a week. Participants were also asked how many hours they engaged in puzzles at any given time: 0-1 hour, 1-2 hours, 3-4 hours, 4-5 hours, 5-6 hours, 6-7 hours, and 8+ hours.

**Motivation.** Measures of motivation were also part of the questionnaire as it was thought that varying levels of motivation during the experiment could have an affect on their performance. Participants filled out self-reports about their level of motivation when engaging in both the puzzle-tasks and brainstorming problems. Participants self-reported their level of motivation on a Likert scale ranging from 1 = unmotivated to 5 = highly motivated.

**Enjoyment.** Participants were asked whether they enjoyed any one or more of the three brainstorming problems. Participants were also asked to rate their level of enjoyment when engaging in the puzzle-tasks ranging from 1 = lowest enjoyment to 5 = highest enjoyment.

**Usability.** Participants were asked if they felt the puzzle-task was user friendly on a five-point Likert scale as follows: strongly agree, agree, neutral, disagree, and strongly disagree.
CHAPTER IV
RESULTS

The goal of the present study was to examine whether the effects of cognitive flexibility training (i.e., puzzle-task) could increase higher levels of flexible thinking on subsequent brainstorming tasks. It was hypothesized that participants who were trained in the High Flexibility group would increase their flexible thinking and thus generate a greater number of ideas and generate more creative ideas than those in the Low Flexibility group.

Pilot Study Results

The pilot study examined the effects of cognitive flexibility training (Weak and Strong) on subsequent brainstorming tasks by measuring the number of ideas generated. Table 1 displays the means and standard deviations of scores of completed puzzle-tasks, ideas generated, and creative ideas generated as a function of the type of cognitive flexibility training (Weak and Strong Flexibility) across the three trial blocks. The 2 X 3 ANOVA revealed a significant difference in the number of ideas generated between the three trial blocks; $F(2, 106) = 5.44, p < .006$, $\text{partial } \eta^2 = .093$. Pairwise comparisons showed that there were significant mean differences at $p < .05$ between Trial blocks one and Trial blocks three, and Trial blocks two and Trial blocks three. However, the main interest was in examining the effects of cognitive flexibility training (Weak and Strong Flexibility) on the number of ideas generated by the participants (see Figure 3). The results revealed that there was no significant main effect of cognitive flexibility training on the number of ideas generated across the three trial blocks, $F(2, 104) = .521, p = .47$, $\text{partial } \eta^2 = .009$. When measuring the number of creative ideas, two independent raters
examined each of the ideas and rated the number of creative ideas generated across all three trials, but a weak correlation ($r = .44$) was found between the two raters. When looking at the main effects of cognitive flexibility between the Low and High groups on the number of creative ideas (see Figure 4) that were generated across the three trial blocks, no significant differences were found, $F (2, 106) = .081, p = .922, partial \eta^2 = .002$.

Table 1

*Means Scores and Standard Deviations for Each Flexibility Group and Each Trial Block in the Pilot Study*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Puzzle-Task Mean (SD)</th>
<th>Ideas Generated Mean (SD)</th>
<th>Creative Ideas Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Flexibility</td>
<td>14.40 (4.70)</td>
<td>12.80 (4.82)</td>
<td>4.40 (2.23)</td>
</tr>
<tr>
<td>Trial 1</td>
<td>12.11 (4.13)</td>
<td>13.85 (5.54)</td>
<td>4.57 (3.05)</td>
</tr>
<tr>
<td>Trial 2</td>
<td>15.48 (5.04)</td>
<td>13.52 (6.55)</td>
<td>4.81 (3.33)</td>
</tr>
<tr>
<td>Trial 3</td>
<td>15.59 (5.44)</td>
<td>11.04 (5.34)</td>
<td>3.81 (2.37)</td>
</tr>
<tr>
<td>High Flexibility</td>
<td>13.46 (3.21)</td>
<td>15.04 (5.93)</td>
<td>3.98 (2.26)</td>
</tr>
<tr>
<td>Trial 1</td>
<td>10.57 (2.69)</td>
<td>15.14 (8.75)</td>
<td>4.50 (2.75)</td>
</tr>
<tr>
<td>Trial 2</td>
<td>14.39 (3.66)</td>
<td>16.40 (5.80)</td>
<td>4.11 (3.42)</td>
</tr>
<tr>
<td>Trial 3</td>
<td>15.43 (3.84)</td>
<td>13.59 (6.46)</td>
<td>3.32 (2.28)</td>
</tr>
</tbody>
</table>

*Note.* Rows for both the Low and High Flexibility conditions in all three columns (puzzle-task, ideas generated, and creative ideas) represent the overall mean scores and standard deviations across all three trials. The remaining trial rows represent mean scores
and standard deviations separated by each trial block.

\[ \text{Figure 1. Mean number of times the puzzle-task was solved between the High and Low Flexibility groups.} \]

\[ \text{Figure 2. Mean number of ideas generated between the High and Low Flexibility groups.} \]
Figure 3. Mean number of creative ideas rated by two experimenters between the Low and High Flexibility groups.

**Present Study Results**

The present study was conducted with the most recent puzzle-task version developed by Gonzalez et al. (2012). The research questions that were examined in the pilot study were also investigated in the present study. Additional features were added to the puzzle-task, including post questionnaire measures that were not added in the previous pilot study.

A 2 X 3 mixed ANOVA was used to analyze the results in the present study to examine differences in the number of ideas generated and the level of creativity between the Low and High Flexibility groups. Three master lists were created for each brainstorming problem and was organized accordingly in terms of appropriate categories,
and each list was examined to ensure that no similar ideas appeared twice. The master list for the tourists’ problem included a total of 134 different ideas. For the thumbs’ problem, a total of 104 different ideas were generated, and for the teachers’ problem a total of 132 different ideas were generated.

It was hypothesized that the High Flexibility group would produce a greater number of ideas and demonstrate higher levels of creativity across three trial blocks than the Low Flexibility group as a result of the cognitive flexibility training (i.e., puzzle-task). First, the High Flexibility group was required to switch rules at minimum between 30% and at maximum 50% percent above than what was required by the Low Flexibility group. The High Flexibility group was expected to produce a greater number of ideas across the three trial blocks. Using Wilks’ Lambda criterion, there were no significant main effect (Wilks’ Lambda = .989, $F(2, 70) = .405, p = .668, \text{partial } \eta^2 = .011$) of the Low and High Flexibility groups on the number of ideas generated. However, there was a significant difference (Wilks’ Lambda = .916, $F(2, 70) = 3.22, p = .046, \text{partial } \eta^2 = .084$) in the number of ideas generated between the three trial blocks. Second, it was hypothesized that the High Flexibility group would have higher creativity scores than the Low Flexibility group. When looking at the level of creativity, there was no significant main effect (Wilks’ Lambda = .983, $F(2, 70) = .606, p = .548, \text{partial } \eta^2 = .017$) between the Low and High Flexibility groups. In addition, there were no significant differences (Wilks’ Lambda = .944, $F(2, 70) = 2.06, p = .135, \text{partial } \eta^2 = .060$) in the level of creativity across the three trial blocks.
Table 2.

*Means Scores and Standard Deviations for Each Flexibility Group and Each Trial Block*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Puzzle-Task Mean (SD)</th>
<th>Ideas Generated Mean (SD)</th>
<th>Creativity Score Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Flexibility</td>
<td>28.81 (1.48)</td>
<td>7.29 (2.48)</td>
<td>91.49 (24.14)</td>
</tr>
<tr>
<td>Trial 1</td>
<td>27.11 (3.66)</td>
<td>7.58 (3.23)</td>
<td>94.68 (43.62)</td>
</tr>
<tr>
<td>Trial 2</td>
<td>29.41 (1.44)</td>
<td>7.49 (2.84)</td>
<td>96.41 (56.93)</td>
</tr>
<tr>
<td>Trial 3</td>
<td>29.92 (.28)</td>
<td>6.84 (3.29)</td>
<td>83.38 (48.71)</td>
</tr>
<tr>
<td>High Flexibility</td>
<td>24.56 (4.95)</td>
<td>7.86 (3.57)</td>
<td>86.44 (31.29)</td>
</tr>
<tr>
<td>Trial 1</td>
<td>20.19 (4.37)</td>
<td>8.58 (4.91)</td>
<td>100.89 (58.41)</td>
</tr>
<tr>
<td>Trial 2</td>
<td>26.25 (5.49)</td>
<td>7.75 (3.63)</td>
<td>81.00 (51.65)</td>
</tr>
<tr>
<td>Trial 3</td>
<td>27.33 (5.83)</td>
<td>7.25 (3.76)</td>
<td>77.44 (50.50)</td>
</tr>
</tbody>
</table>

*Note.* Rows for both the Low and High Flexibility conditions in all three columns (puzzle-task, ideas generated, and creativity score) represent the overall mean scores and standard deviations across all three trials. The remaining trial rows represent mean scores and standard deviations separated by each trial block.

Comparing the average number of completed puzzles across the three trial blocks there was a main effect of the Low and High cognitive flexibility (Wilks’ Lambda = .710, \(F (2, 70) = 14.28, p < .001, partial \eta^2 = .290\)) between the Low and High Flexibility group. However, Mauchly’s Test of Sphericity was significant indicating that the assumption was violated. Using Huynh-Feldt for the corrected tests, \(F (1.60, 195.35) = 21.14, p < .001, partial \eta^2 = .23\) results demonstrated that the Low Flexibility group completed significantly more puzzles than the High Flexibility group across all three
Table 3.

**Mean Times (milliseconds) and Standard Deviations for Overall Time to Complete the Puzzles, Average Time for Perseverative Moves, and Average Time for Non-perseverative moves.** *PM = (perseverative move), NPM = (non-perseverative move)*

<table>
<thead>
<tr>
<th>Puzzle-task</th>
<th>Trial #1</th>
<th>Trial #2</th>
<th>Trial #3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Flexibility</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Time</td>
<td>21302.2 (4375.7)</td>
<td>17250.93 (3127.87)</td>
<td>15689.17 (2166.25)</td>
</tr>
<tr>
<td>Average Time</td>
<td>1121.17 (230.3)</td>
<td>907.94 (164.62)</td>
<td>825.75 (114.01)</td>
</tr>
<tr>
<td>PM</td>
<td>1071.14 (222.73)</td>
<td>830.51 (157.59)</td>
<td>753.83 (105.62)</td>
</tr>
<tr>
<td>NPM</td>
<td>1691.86 (375.28)</td>
<td>1316.21 (242.78)</td>
<td>1210.1 (200.53)</td>
</tr>
<tr>
<td><strong>High Flexibility</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Time</td>
<td>30282.84 (8636.58)</td>
<td>23303.11 (5395.25)</td>
<td>21573.4 (4781.3)</td>
</tr>
<tr>
<td>Average Time</td>
<td>1593.83 (454.56)</td>
<td>1226.48 (283.96)</td>
<td>1135.44 (251.65)</td>
</tr>
<tr>
<td>PM</td>
<td>1335.95 (377.79)</td>
<td>1048.38 (239.98)</td>
<td>971.05 (232.86)</td>
</tr>
<tr>
<td>NPM</td>
<td>1796.18 (515.48)</td>
<td>1357.85 (336.26)</td>
<td>1254.95 (285.11)</td>
</tr>
</tbody>
</table>

*Note.* Rows for both the Low and High Flexibility conditions in all three columns (Average time to complete the puzzle-tasks, average time for perseverative moves, average time for non-perseverative moves) represent the overall mean times and standard deviations across all three trials.
Figure 4. Mean number of ideas generated between the Low and High Flexibility groups.

With regard to brainstorming, participants were asked questions whether they enjoyed one or more of the brainstorming problems, and whether it was more important in their opinion to come up with one creative idea, many ideas, or both. Results found that 49.3% of the participants enjoyed the thumbs’ problem, 37% enjoyed the tourists’ problem, and 17% enjoyed the teachers’ problem. About 56% felt that it was more important to come up with many ideas, 28% felt that it was important to come up with one creative idea, 13% felt that both were equally important, and 3% answered as not knowing. With regard to the Low and High Flexibility groups, there were no significant differences between the groups responses.

With regard to usability, a cumulative 81.7% of the participants agreed or strongly agreed that the puzzle-task was user friendly, and this corresponds with results from Gonzalez et al. (2012). This was to ensure the puzzle-task did not interfere with the participants’ ability to successfully engage in the puzzle throughout the experimental
session. In addition, practice sessions were employed at the beginning of the experiment to familiarize the participants with the puzzle-task interface.

Video game playing behavior was also analyzed. Forty percent of the participants reported playing video games at their leisure, and of those participants, 46.6% reported playing between 0-1 hours a day, 23% reported playing 1-2 hours at a time, 4% said they played 3-4 hours, and the same percentage reported that they played 4-5 hours. Twenty-six percent reported playing games once a week, 8.2% reported 1-2 times a week, 6.8% reported playing 2-3 times a week, 4.1% reported playing 3-4 times a week, and 2.7% reported playing four or more times a week. The self-report survey also asked the participants what genre of video games they typically play, and of those participants, 37% played action and adventure, 30% played adventure, 28.8% played strategy, 28.8% played shooters, 17.8% played role playing games (RPG), 9.6% played massive multiplayer online RPG, 35.6% played racing games, and 21.9% played music playing games (e.g., Rock Band, Guitar Hero).

Bivariate Pearson Correlations were used to determine if video game playing correlated with ideational fluency and creative performance. No significant correlation ($r = .15, ns.$) was found between video game playing and ideational fluency. In addition, there was no significant relationship ($r = -.04, ns.$) between video game playing and creativity.
CHAPTER V
DISCUSSION

The primary objective of this thesis was to examine whether cognitive flexibility training increases ideational fluency and creative performance on subsequent brainstorming tasks. It was originally hypothesized that participants training in the High Flexibility group would generate significantly more ideas and higher creativity scores than the Low Flexibility group. The results were not as predicted; the use of the cognitive flexibility training puzzle-task (Gonzalez et al., 2012) was not found to be an effective training tool to improve cognitive flexibility for idea generation and creative performance on brainstorming tasks.

Despite finding no significant differences in the number of ideas generated between the two groups, the High Flexibility group did however generate more ideas than the Low Flexibility group across all three trial blocks, and this finding was a consistent trend in both the pilot study and present study. The cognitive flexibility training may have produced a short and temporary effect during the first brainstorming task, and the effect may have worn off towards the end of the experiment. Sample sizes in the present study may also have been a factor. Interestingly, the number of ideas generated by both groups decreased over time across the three trial blocks, and this trend was seen in both the pilot study and the present study, which may have been due to a fatigue effect explaining why this result occurred. On the other hand, participants demonstrated increased levels of performance on the puzzle-task across the three trials. It may not be fully clear as to why the number of ideas decreased across the trial blocks because results indicated that there was a positive relationship between motivation and the brainstorming
problems, and it may be the length of the experimental session caused the fatigue in performance and breaks between each trial block were not employed.

For the creativity scores, the experimenter prepared master lists for each brainstorming problem by listing every non-redundant idea and scoring each idea based on the frequency in which that idea occurred. For the tourists’ problem, the lowest creativity score for a repeated idea was 30. For the thumbs’ problem the lowest score was a 54, and for the teachers’ problem a score of 33. Again, the highest creativity score a participant could earn was a score of one, indicating that it was the only idea within its category and no other participant had generated the same idea. Final creativity scores were summed up for each of the participants’ ideas based on the master lists.

Comparisons across all three trial blocks between the Low and the High Flexibility groups showed no significant differences in the level of creativity. One experimenter prepared the master lists and scored all the ideas because a second experimenter to analyze the list was unavailable due to time constraints. For future studies, two independent raters should carefully examine the master list using the present method of scoring to establish interrater reliability. Furthermore, Taylor et al. (1958) used a different creativity scoring method by measuring the originality and quality of the ideas based on three parameters (i.e., feasibility, effectiveness, generality). This technique also required that two independent raters separately examine the ideas.

Results from the number of completed puzzle-tasks demonstrated significant differences between the Low and High Flexibility groups across all three trial blocks. The Low Flexibility group completed significantly more puzzles than the High Flexibility group. One explanation for this finding may be due to the frequent rule switching
required by the High Flexibility group. Ultimately, switching between rules more often
takes up more cognitive resources, increasing the participants’ cognitive load, and thus
caus[110]ng the High Flexibility group to take longer to complete the puzzles. Results from
the pilot study demonstrated similar results. Interestingly, both Flexibility groups
increased their performance completing more puzzles across the three trial blocks. A
possible practice effect may have occurred as they became more effective at switching
rules from the cognitive flexibility training.

Similarly, there were differences between the Low and High Flexibility group in
the overall time it took to solve the puzzles. Consistent with findings in the number of
completed puzzle-tasks, the High Flexibility group took significantly longer to solve the
puzzle-task than the Low Flexibility group across all three trials. Again, this may have
been attributed to the high cognitive load from switching more rules that were
encountered by the High Flexibility group. However, both Flexibility groups increased
their overall time to complete the puzzles, suggesting that the puzzle task produced a
practice effect consistently across all three trial blocks.

When looking at the average times between each move across the three trials,
there were significant differences the two flexibility groups. The High Flexibility group
on average took significantly longer to make a move regardless of whether it was a
perseverative move (i.e., when a switching rule was required) or a non-perseverative
move (i.e., when no switching rule was required). This result was attributed to the greater
number of perseverative moves that were required by the High Flexibility group, taking
them longer to successfully complete the puzzle-tasks. However, no significant
differences were found when looking at perseverative and non-perseverative moves
Bivariate Pearson correlations were used to determine whether fatigue was a possible factor that resulted in the consistent decrease in ideational fluency for both groups across all three trials. Results revealed that there was a significant and positive relationship ($r = .32, p < .01$) between motivation and the raw total number of ideas generated from each brainstorming task. In other words, motivation does become an important factor when it comes to generating ideas. However, there was no significant correlation between the participants’ level of enjoyment and the number of completed puzzle tasks ($r = .06, ns.$).

Data regarding the participants’ video game playing behavior was collected in the study. However, when analyzing those individual differences in video game playing behavior, no significant differences were found between ideational fluency and creativity. These questions were asked because prior research by Jackson, Witt, Games, Fitzgerald, von Eye, and Zhao (2011) suggested that those who play video games regardless of the genre (i.e., violent or non-violent) are more likely to exhibit greater creative performance than those who do not on certain creativity tasks (e.g., Torrance Test of Creativity). However, the findings from that study may not be applicable to the present study because their sample population consisted of 12-year olds.

In summary, findings in the present study do not establish that engaging in cognitively flexible tasks has short-term transfer effects of increasing ideational fluency and creative performance on subsequent brainstorming tasks. Even though the results were not as predicted, it is possible that engaging in a cognitively flexible task increases creative performance across other domains that include real-world creativity and
innovation like artistic creation, design, or poetry writing.

**Research Implications**

Researchers have long studied creativity, but more specifically they have studied what mechanisms foster and maximize creative performance across various domains (Baer, 1998). However, previous research has demonstrated positive effects of cognitive training studies, some of which include increasing working memory capacities using video game like features which increase motivation and engagement, all of which are factors that influence creative performance (Jaeggi, Buschkuehl, Jonidas, & Shah, 2011). Future versions of the puzzle-task will aim to create features that could in turn increase levels of enjoyment when engaging in the puzzle-task. Because studies of creative performance are primarily concerned with the production of something that is novel and useful, it is central to understanding what factors will most likely enhance creative performance (Mumford & Gustafson, 1988).

More importantly, educators and psychologists are primarily concerned that there is currently a lack of creativity in the classroom curriculum because of the potential conflicts in policy and practice (Craft, 2003; Spendlove, 2010). However, there has been a growing interest in the topic of creativity in the last several decades (Amabile et al., 1996), and psychologists have been trying to bridge the applications of creativity in the classroom curriculum by understanding key factors that are required to stimulate and foster creative behavior (Craft, 2003). In addition, the results of this study present possible pathways to exercising creative behavior in the classroom without having to deviate from policy driven curriculum.
Limitations

There are several limitations to this study. First, the current prototype of the puzzle-task (Gonzalez et al., 2012) is currently still under development and undergoing further usability testing. In addition, future versions of the cognitive flexibility puzzle will undergo more studies to determine whether the puzzle-task is a valid assessment of cognitive flexibility. Secondly, future studies should also consider looking at different sample populations to assess developmental differences, as well as individual differences in cognitive flexibility.

In addition, findings in this study cannot be generalized to other non-college populations. It is possible that the college population possess certain characteristics that influence creative behavior differently than other non-college populations, as well as those with specific disorders that may inhibit or enhance creative performance. Despite that the groups acted as their own control group, another limitation is that no true control group was included to examine whether there are differences in the absence of a cognitive flexibility training.

Conclusion

A better understanding of creative performance and potential in cognitive flexibility training has important implications. For researchers, the ability to identify specific factors that influence creative achievement such as cognitive flexibility could be advantageous to individuals who continually engage in tasks that require flexible thinking. Although, it may be unclear whether cognitive flexibility training has any effects on creative performance, however, it may increase creative performance in the short-term. Using cognitive flexibility training may strengthen the creative potential
across various domains.
REFERENCES


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APPENDIX A

Pilot Study example of the practice puzzle-task for both the Low and High Flexibility
APPENDIX B

The hand drawing that was used for the Thumbs problem
THE U.S. businessman has always been dependent on new ideas for survival and growth, but never has he been more determined in his search for new ways of doing things than today. To spur "creativity," businessmen will try anything, from the venerable suggestion box to such freewheeling idea-association techniques as "group thinks," "buzz sessions," "imagineering," and the most popular device of all, the "brainstorm."

Originator of the brainstorm* is Alex F. Osborn of Manhattan's Batten, Barton, Durstine & Osborn, who defines it as a method in which groups of people "use their brains to storm a creative problem and do so in Commando fashion, with each stormer audaciously attacking the same objective."

Originated some 15 years ago, brain-storming was extended by BBDO to its clients in 1953, has since spread throughout industry. The advertising agency now has a Vice President in Charge of Brainstorming, whose major function is to hold about three brainstorm sessions a week, see to it that his charges sound off loud and clear. The panel of thinkers is made up of admen and (at nonconfidential sessions) outside guests and friends (including housewives). They sit around in a comfortable, yellow-painted (yellow is considered conducive to thought) brainstorm room furnished in homey knotty pine, have plenty of pads, pencils and cigarettes. Lunch is served, then the session begins. A central problem (how to cut down absenteeism, how to improve highway signs) is presented, and everyone storms ahead. No idea is too fantastic; a cardinal rule is that no one laughs at an idea. If anyone is thoughtless enough to say "It won't work," he is sternly
reminded that such remarks are taboo by the chief brainstormer who clangs a schoolmarm's bell at him. Anyone is free to "hitchhike" on an idea, i.e., pick it up and improve on it. The result is usually that anywhere from 60 to 150 rapid-fire ideas are suggested. The vast majority are usually as impractical as the suggestion by one woman that autos have locomotive-type cowcatchers to nudge pedestrians out of the way. But if later evaluation shows that half a dozen of the ideas are potential solutions to the problem, the brainstorm session is considered a howling success. Says Brainstormer Osborn: "People come to realize that they do have this thing called creative imagination, and that they can be good at it."

To date, more than 75 U.S. companies have asked BBDO to train their staffs in the techniques of brainstorming. Corning Glass came looking for new ways to use glass in autos; General Electric wanted to improve its company newspaper; Armstrong Cork Co. was at a loss over how to celebrate Inventors' Night for 104 employees who had won patents for new processes. In the same way, hundreds of other companies have set up their own brainstorm sessions for plant personnel, modified the idea for their own use. B. F. Goodrich Co., for example, likes to use nontechnical workers to help solve tough engineering problems. At its first "creative workshop" session eight months ago, a white-collar office worker sparked the answer to the problem of how to design a new tire machine; he had attacked the problem without any preconceived technical notion that it was impossible. Motorola's President Robert Galvin has set up a special "idea clinic" along much the same lines. Motorola's ticket of admission to the clinic is a list of 10-25 ideas on a company problem. Then the lucky thinkers spend a free weekend at a luxurious hotel or country club chewing over their ideas, looking for the best solution.
Says Galvin: "What we have accomplished is to create an atmosphere where people don't mind making unusual suggestions in conferences. We've found that we can sometimes get through certain problems more quickly. A rash idea may prompt a useful one."
APPENDIX D

Pilot Study example of the practice puzzle-task for both the Low and High Flexibility
APPENDIX E

Pilot study example of the Low Flexibility Puzzle-task
APPENDIX F

Pilot study example of the High Flexibility Puzzle-task
APPENDIX G

An example of the final study practice puzzle-task
APPENDIX H

An example of the Low Flexibility puzzle-task
APPENDIX I

An example of the High Flexibility puzzle-task
APPENDIX J

6. Do you play video games at your leisure? □ Yes □ No

7. If yes, how often do you play video games in a typical week?
□ Once a week □ 1-2 times a week □ 2-3 times a week □ 3-4 times a week □ 4+ times a week

8. How many hours at a time do you typically play video games?
□ 0-1 hour □ 1-2 hours □ 3-4 hours □ 4-5 hours □ 5-6 hours □ 6-7 hours □ 8+ hours

9. What genre of video games do you typically play? (Check all that apply).
□ Action-Adventure □ Adventure □ Strategy □ Puzzles □ Shooters □ Role-playing □ MMORPG (Massive Multiplayer Online Role Playing Game) □ Racing □ Music playing

10. Do you engage in puzzles or puzzle games? (e.g., Sudoku, crosswords, scrabble, etc).
□ Once a week □ 1-2 times a week □ 2-3 times a week □ 3-4 times a week □ 4+ times a week

11. How many hours at a time do you typically engage in puzzles?
□ 0-1 hour □ 1-2 hours □ 3-4 hours □ 4-5 hours □ 5-6 hours □ 6-7 hours □ 8+ hours

12. Do you consider yourself a “creative” person? □ Yes □ No

13. Which of the three brainstorming tasks did you enjoy the most? (Check all that apply)
□ Teachers problem □ Thumbs problem □ Tourists problem

14. When engaging in the brainstorming tasks, was it more important for YOU to come up with many ideas or just one creative idea? □ Many ideas □ One creative idea □ Don’t know □ Both

15. How would you rate your motivation when engaging in the brainstorming tasks?
(5 highly motivated – 1 unmotivated)
□ 1 □ 2 □ 3 □ 4 □ 5
16. How would you rate your enjoyment of the puzzles? (1 lowest enjoyment – 5 highest enjoyment)
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

17. The puzzle task was user friendly.
☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

18. How motivated were you to complete the puzzles? (5 highly motivated – 1 unmotivated)
☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1